US006712080B1

(12) **United States Patent**
Handschuh et al.

(10) **Patent No.: US 6,712,080 B1**
(45) **Date of Patent: Mar. 30, 2004**

(54) **FLUSHING SYSTEM FOR REMOVING LUBRICANT COKING IN GAS TURBINE BEARINGS**

(75) Inventors: **Robert F. Handschuh**, North Olmsted, OH (US); **Gary L. Farley**, Yorktown, OH (US)

(73) Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, DC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 114 days.

(21) Appl. No.: **10/075,282**

(22) Filed: **Feb. 15, 2002**

(51) **Int. Cl.**[7] **B08B 3/08**
(52) **U.S. Cl.** **134/95.1**; 134/99.1; 134/103.1; 134/105
(58) **Field of Search** ..... 134/94.1, 95.1, 134/97.1, 99.1, 99.2, 103.1, 105, 111, 166 R, 116, 169 R, 169 A, 113

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,074,822	A	*	1/1963	Walk et al.
3,486,582	A	*	12/1969	Carter et al.
4,046,155	A	*	9/1977	Mansson
4,059,123	A	*	11/1977	Bartos et al.
4,065,322	A	*	12/1977	Langford
4,196,020	A	*	4/1980	Hornak et al.
4,309,870	A	*	1/1982	Guest et al.
4,377,420	A	*	3/1983	Granatek et al.
4,424,665	A	*	1/1984	Guets et al.
4,698,130	A	*	10/1987	Restall et al.
4,891,934	A	*	1/1990	Huelster
5,273,395	A	*	12/1993	McDermott
5,868,860	A	*	2/1999	Asplund
5,938,402	A	*	8/1999	Bochud et al.
5,944,483	A	*	8/1999	Beck et al.
6,073,637	A	*	6/2000	Hayward et al.
6,310,022	B1	*	10/2001	Amiran
6,475,290	B2	*	11/2002	Jones
6,503,334	B2	*	1/2003	Ruiz et al.

FOREIGN PATENT DOCUMENTS

WO	WO 92/14557	*	9/1992

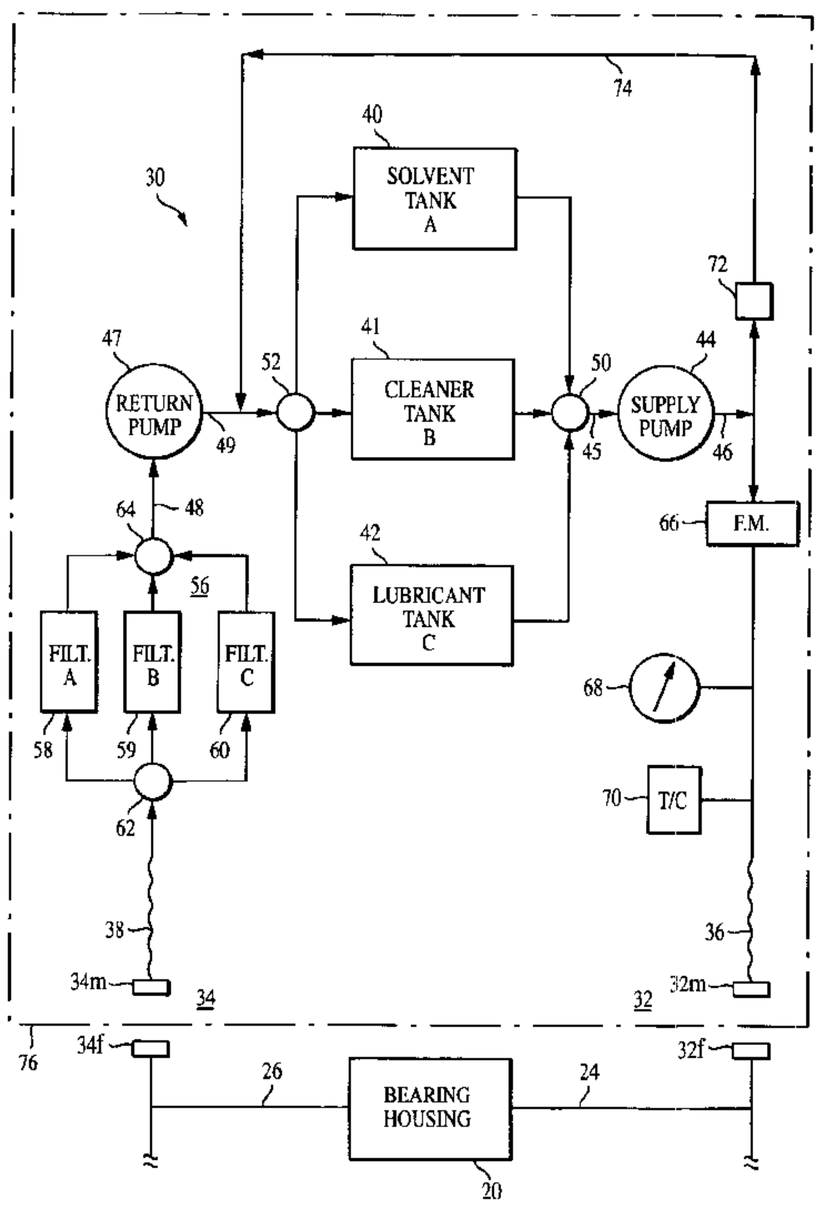
* cited by examiner

Primary Examiner—Frankie L. Stinson
(74) *Attorney, Agent, or Firm*—William Randolph

(57) **ABSTRACT**

A flushing system for flushing away any coking material which may have built up in the bearing of a gas turbine. Three fluid tanks respectively contain a solvent for dissolving the coked material, a cleaner and a lubricant. By means of a three-way valve, one of the fluids is provided to a supply pump for delivery to the bearing housing via a quick disconnect coupling. Fluid is returned to the appropriate tank by means of a return pump, via a quick disconnect coupling and another three-way valve between the return pump and the tanks. The system includes respective filters for filtering the return fluids and the entire system may be carried on a wheeled cart for servicing the gas turbine.

11 Claims, 2 Drawing Sheets



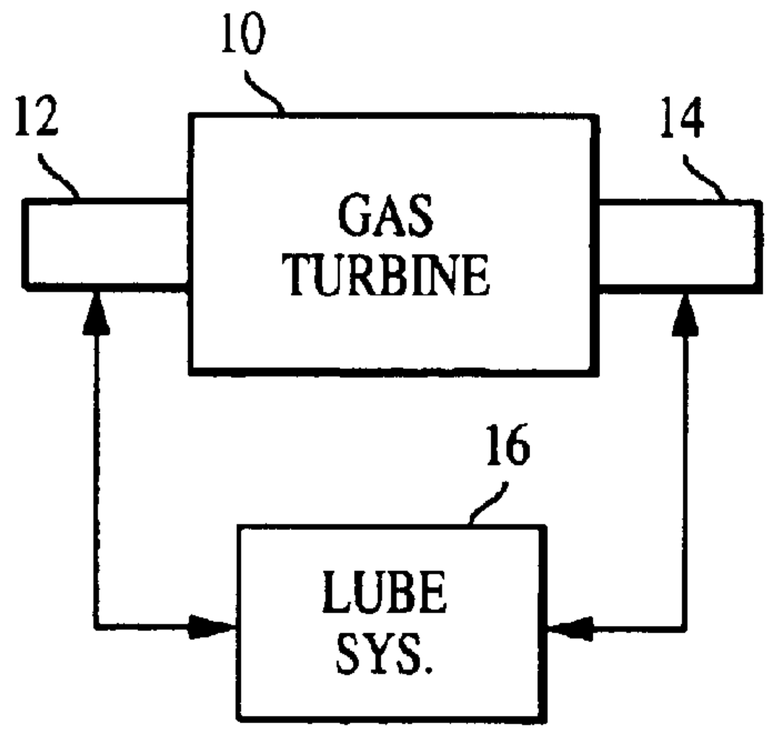

10
12
14
GAS
TURBINE
16
LUBE
SYS.

FIG. 1

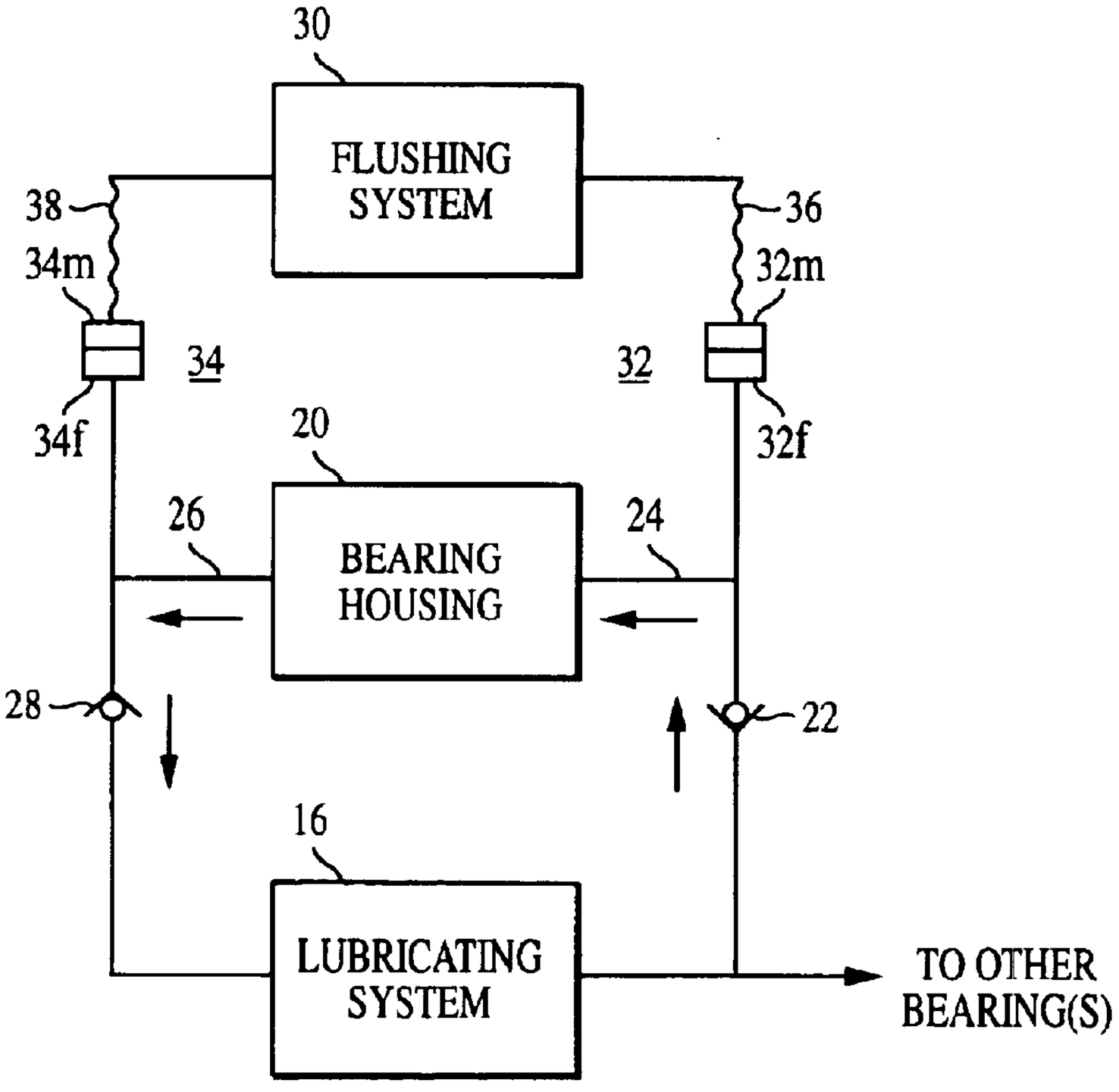

30
FLUSHING
SYSTEM
38
34m
36
32m
34
32
34f
32f
20
26
24
BEARING
HOUSING
28
22
16
LUBRICATING
SYSTEM
TO OTHER
BEARING(S)

FIG. 2

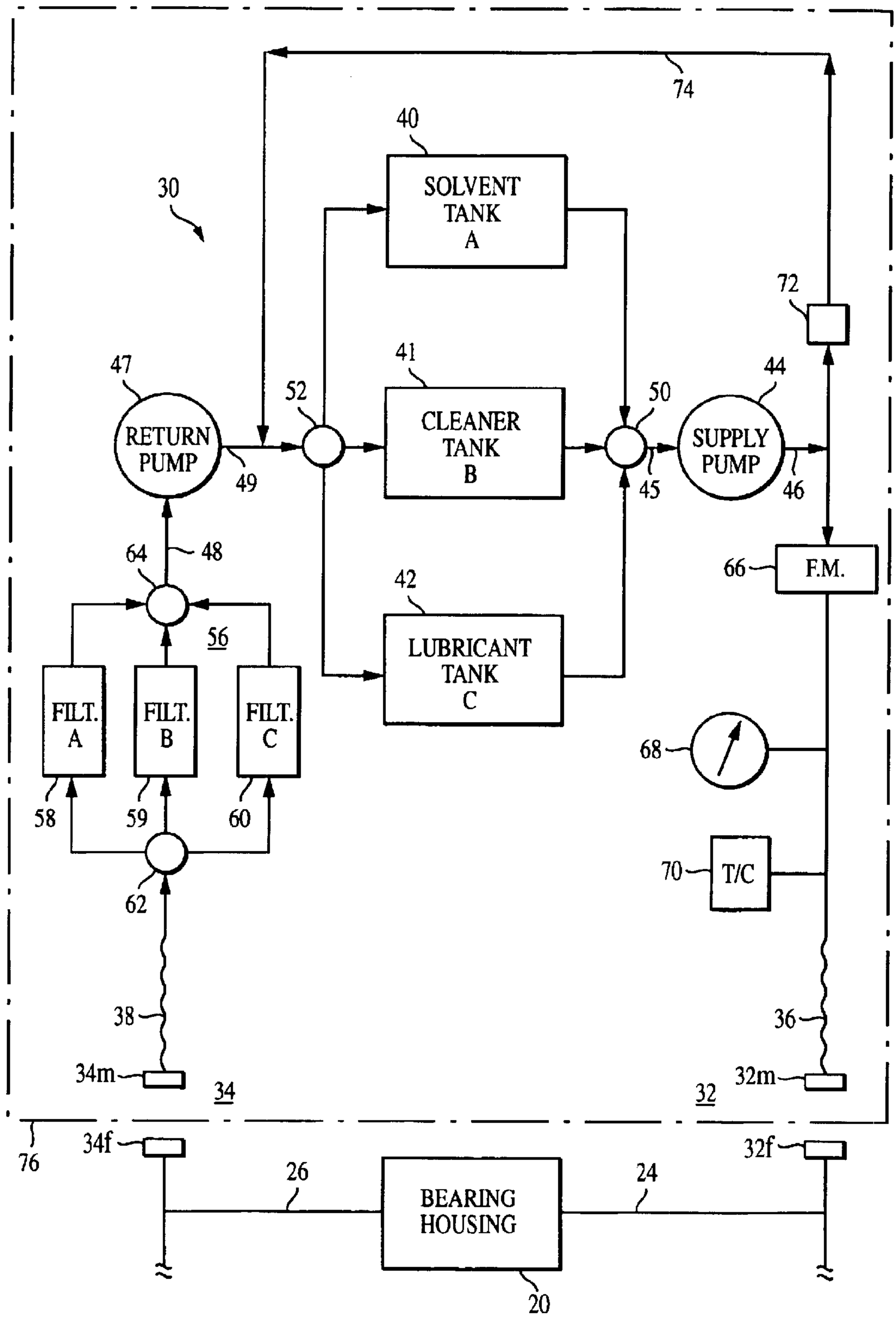

74
40
SOLVENT TANK A
30
72
47
41
52
50
44
RETURN PUMP
CLEANER TANK B
SUPPLY PUMP
49
45
46
64
48
66
F.M.
42
56
LUBRICANT TANK C
FILT. A
FILT. B
FILT. C
68
58
59
60
T/C
70
62
38
36
34m
32m
34
32
76
34f
32f
26
24
BEARING HOUSING
20

FIG. 3

FLUSHING SYSTEM FOR REMOVING LUBRICANT COKING IN GAS TURBINE BEARINGS

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for government purposes without the payment of any royalties therefor.

BACKGROUND OF THE INVENTION

Gas turbines, including those used for propelling military vehicles, include two or more opposed bearings which must be continuously lubricated during gas turbine usage. This is accomplished by means of a lubricating system which provides the bearings with a lubricating fluid, such as natural or synthetic oil, to not only lubricate the bearings but to also provide for cooling.

When the gas turbine is shut down after usage, the residual heat from the turbine (which may be hundreds of degrees Fahrenheit) soaks back to the bearings leading to a possible coking condition. This is even more pronounced if there is insufficient engine idle time before turbine shut down. Basically, coking is the result of the lubricant becoming an oxidized solid oil deposit on the bearing surface and in the lubricant delivery system that can lead to insufficient lubricant supply to the bearings. This can result in engine seizure and/or a requirement for a complete engine overhaul, which is undesirable, particularly in tactical combat situations.

Accordingly, it is a primary object of the present invention to provide apparatus which flushes away the coked lubricant in rotating machinery bearings, particularly, in gas turbines which shut down at high temperatures.

SUMMARY OF THE INVENTION

A flushing system for removing lubricant coking in a turbine bearing, within a bearing housing having a fluid inlet and fluid outlet, includes a plurality of fluid containing tanks, at least a first of which contains a coking solvent, a second of which contains a cleaner and a third of which contains a lubricant. First and second couplings are provided with a first coupling being connected to the fluid inlet and the second coupling being connected to the fluid outlet, of the bearing housing. A supply pump has an outlet connected to the first coupling, and a return pump has an inlet connected to the second coupling. A first valving arrangement is connected between the tanks, and an inlet of the supply pump, and is operable to provide fluid from a selected one of the tanks to the supply pump for delivery to the bearing housing. A second valving arrangement is connected between an outlet of the return pump and the tanks, to supply return fluid from the bearing housing to the particular tank selected by the first valving arrangement.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood, and further objects, features and advantages thereof will become more apparent from the following description of the preferred embodiment, taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a simplified block diagram of a gas turbine and lubricating system.

FIG. **2** is a block diagram of the flushing system of the present invention, attached to a bearing as in FIG. **1**.

FIG. **3** is a more detailed presentation of the flushing system of FIG. **2**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the drawings, which are not necessarily to scale, like or corresponding parts are denoted by like or corresponding reference numerals.

In FIG. **1**, a rotating gas turbine **10** is supported by opposed first and second bearings **12** and **14**, although, more such bearings may be utilized, depending upon turbine size and design.

A lubricating system **16** is provided in order to supply the bearings with necessary lubrication and cooling during use, and when the gas turbine **10** shuts down, the lubrication system **16** also shuts down, leading to a possible coking condition, as previously explained. The present invention obviates this problem by flushing away any coked deposits, and to this end, reference is made to FIG. **2**.

In FIG. **2**, the lubricating system **16** is illustrated as being connected to a representative bearing housing **20** for delivering lubricating fluid to the bearing, via a one-way valve **22** and fluid inlet **24**, and for receiving used lubricant from the bearing, via fluid outlet **26** and one-way valve **28**. Flushing system **30** is connectable with the bearing housing inlet **24** by means of coupling **32** and is connectable with the bearing housing outlet **26** by means of coupling **34**.

The flushing system **30** may be a permanent installation in a maintenance facility, or, may be a portable system in which a system carrier is wheeled up to the gas turbine-driven vehicle. To facilitate rapid servicing, the couplings **32** and **34** are preferably of the threadless quick-disconnect type which have respective male connectors **32***m* and **34***m*, which mate with respective female connectors **32***f* and **34***f*. When uncoupled, the female connectors **32***f* and **34***f* prevent fluid from exiting the connector. The portable system also includes respective flexible hoses **36** and **38**, which may be wound up upon the carrier.

A more detailed view of the flushing system **30** is presented in FIG. **3**. After the gas turbine on the vehicle has shut down, the flushing system **30** is wheeled up to the vehicle and is connected to the bearing inlet **24** and outlet **26** by unwinding the flexible hoses **36** and **38** and by bringing together the respective connectors of couplings **32** and **34**.

The flushing system **30** includes a plurality of fluid holding tanks **40–42**, a first of which contains a solvent for dissolving any coked oil. By way of example the solvent may be a 50-50 solution of tetrahydrofuran and cyclohexane which turns the coked lubricant into a fine powder. A second tank, **41**, contains a cleaner, such as alcohol or kerosene, to remove any solvent and dissolved coke material. A third tank, **42**, contains lubricant to re-lubricate the bearings.

By a valving arrangement, the liquids in the tanks **40–42** are selectively provided to the bearing housing **20** via coupling **32**, by means of a supply pump **44**, having an inlet **45** and outlet **46**, and liquid is withdrawn from the bearing housing **20** by means of a scavenge, or return pump, **47**, having an inlet **48** and outlet **49**. More particularly, the valving arrangement includes a first three-way valve **50** which is automatically, or hand operated, to selectively connect supply pump **44** with either solvent tank **40**, cleaner tank **41** or lubricant tank **42**. A similar three-way valve **52** is operative to selectively direct return fluid from return pump **47**, to either solvent tank **40**, cleaner tank **41** or lubricant tank **42**.

Prior to entering the return pump **47**, return fluid from the bearing is preferably filtered. This is accomplished with the

provision of a filter station **56** comprised of three filters **58–60**, one for each of the tanks **40–42**, and selectively put into the fluid circuit by means of three-way valves **62** and **64**. These valves **62** and **64** are operated to direct fluid: A) to filter **58** when solvent from solvent tank **40** is being supplied, B) to filter **59** when cleaner from cleaner tank **41** is being supplied, and C) to filter **60** when lubricant from lubricant tank **42** is being supplied.

In operation, after coupling with the bearing housing **20**, the pumps **44** and **47** of the flushing system **30** are turned on such that, initially, solvent from tank **40** is provided to the bearing with the proper positioning of three-way valves **50**, **52**, **62** and **64**. The solvent is continuously supplied to the bearing for a period of time in order to dissolve the coked material. In order to assist in determining this period of time, a flowmeter **66** is provided in the fluid line from supply pump **44** to the bearing housing **20**. Based upon an increased flow rate of the solvent, as determined by the flowmeter **66**, the valving arrangement may be changed so as to next provide cleaner from tank **41** to remove the solvent from the bearing housing **20**. After another predetermined period of time, the three-way valves are positioned to supply lubricant from tank **42** for a few minutes, to replenish the bearing housing **20** with fresh lubricant prior to a subsequent start-up of the gas turbine.

In order to further monitor the system during the flushing operation, the system also includes a pressure gage **68** and a thermocouple **70**, both of which are connected to the fluid circuit downstream of the supply pump **44**. Additionally, if the pressure in the fluid line exceeds a certain value, a relief valve **72** is operative to direct the fluid from pump **44** back to three-way valve **52** via fluid line **74**. After the complete flushing operation, couplings **32** and **34** are disconnected and the gas turbine-driven vehicle may return to its assigned task.

As mentioned, the flushing system **30** may be completely portable for delivering the system to a gas turbine-driven vehicle for servicing. Accordingly, the components of the flushing system **30** may be carried on a wheeled cart, generally represented by the numeral **76**, in FIG. **3**.

It will be readily seen by one of ordinary skill in the art that the present invention fulfills the primary object set forth herein. After reading the foregoing specification, one of ordinary skill in the art will be able to effect various changes, substitutions of equivalents and various other aspects of the present invention as broadly disclosed herein. It is therefore intended that the protection granted hereon be limited only by the definition contained in the appended claims and equivalents. Having thus shown and described what is at present considered to be the preferred embodiment of the present invention, it should be noted that the same has been made by way of illustration and not limitation. Accordingly, all modifications, alterations and changes coming within the spirit and scope of the present invention are herein meant to be included.

What is claimed is:

1. A flushing system for removing lubricant coking in a turbine bearing, within a bearing housing having a fluid inlet and fluid outlet, comprising:

a plurality of fluid containing tanks, at least a first of which contains a coking solvent, a second of which contains a cleaner and a third of which contains a lubricant;

first and second couplings, said first coupling being connected to said fluid inlet and said second coupling being connected to said fluid outlet, of said bearing housing;

a supply pump having an inlet, and having an outlet connected to said first coupling;

a return pump having an outlet, and having an inlet connected to said second coupling;

a first valving arrangement connected between said plurality of tanks and said inlet of said supply pump and operable to provide fluid from a selected one of said tanks to said supply pump for delivery to said bearing housing;

a second valving arrangement connected between said outlet of said return pump and said tanks to supply return fluid from said bearing housing to said tank selected by said first valving arrangement.

2. A system according to claim **1** wherein:

said first valving arrangement is a three-way valve.

3. A system according to claim **1** wherein:

said second valving arrangement is a three-way valve.

4. A system according to claim **1** wherein:

said first and second couplings are threadless quick-disconnect couplings.

5. A system according to claim **1** which includes:

at least three fluid filters each for filtering a respective one of said fluids returning to said tank selected by said first valving arrangement.

6. A system according to claim **5** wherein:

said filters are positioned in the fluid line between said second coupling and said inlet of said return pump; and which includes

third and fourth valving arrangements for placing a selected one of said filters into the fluid circuit.

7. A system according to claim **1** which includes:

a flowmeter in the fluid circuit between said outlet of said supply pump and said first coupling.

8. A system according to claim **1** which includes:

pressure and temperature sensors positioned for obtaining pressure and temperature readings of the fluid in the fluid circuit between said outlet of said supply pump and said first coupling.

9. A system according to claim **1** which includes:

a fluid line connecting said outlet of said supply pump to said outlet of said return pump; and

a relief valved positioned in said fluid line.

10. A system according to claim **1** wherein:

said flushing system is carried on a wheeled cart.

11. A system according to claim **1** wherein:

said turbine bearing is a gas turbine bearing.

* * * * *